

## CLAIMS:

1. (Currently amended) A current sensor, comprising:

- one middle leg magnetic circuit (1) having opposite ends;
- two outer leg magnetic circuits (2a,2b), each connected to one of the opposite ~~with one and the other~~ ends of the middle leg magnetic circuit(1), respectively;
- an exciting means(3a) arranged in each of the outer leg magnetic circuits (2a) ~~and~~
- ~~an exciting means(3b) arranged in the outer leg magnetic circuit(2b);~~
- a flux detecting means(4) arranged in the middle leg magnetic circuit(1);
- drive means(7) for driving the exciting means(3a) ~~and the exciting means(3b),~~

respectively; and

- a detection circuit(8) connected with the flux detecting means(4) and outputting the electric signals interlocked with the flux being detected by the flux detecting means(4).

2. (Currently amended) A current sensor according to claim 1, further comprising:

- a balance recovery coil(5) arranged by winding a wire around at least one of the middle leg magnetic circuit(1) and the outer leg magnetic circuits(2a,2b);
- a balance recovery current controlling circuit(9) for controlling the balance recovery current run along the balance recovery coil(5) to decrease the flux being detected by the flux detecting means(4), based on the electric signals being output from

the detection circuit(8); and

a detected value outputting circuit(10) for outputting the balance recovery current value.

3. (Currently amended) A current detecting method, comprising:

achieving magnetic balance condition by generating a ~~the~~ first excited flux which is an alternating flux to run along a middle leg magnetic circuit(1) by an exciting means(3a) and generating a ~~the~~ second excited flux, of which the magnitude is the as same as that of the first excited flux and the direction is reverse to that of the first excited flux, the second flux being ~~which~~ is an alternating flux to run along the middle leg magnetic circuit(1) by an exciting means(3b);

achieving magnetic non-balance condition due to collapse of the magnetic balance condition, which is caused by running detected current along a detected wire(6) passed through at least one of a ~~the~~ window which is formed by being surrounded by a first ~~an~~ outer leg magnetic circuit(2a) and the middle leg magnetic circuit(1) and a ~~the~~ window which is formed by being surrounded by a second ~~an~~ outer leg magnetic circuit(2b) and the middle leg magnetic circuit(1) to vary the magnetic reluctance of the first outer leg magnetic circuit(2a) and the second outer leg magnetic circuit(2b); and

detecting the detected current running along the detected wire(6) by detecting the flux which is generated along the middle leg magnetic circuit(1) through achieving the magnetic non-balance condition, by a detection circuit(8) outputting the electric signals interlocked with the flux being detected by a flux detecting means(4).

4. (Currently amended) A current detecting method, comprising:

achieving magnetic balance condition by generating ~~a~~ the first excited flux which is an alternating flux to run along a middle leg magnetic circuit(1) by an exciting means(3a) and generating ~~a~~ the second excited flux, of which the magnitude is the as same as that of the first excited flux and the direction is reverse to that of the first excited flux, the second excited flux being ~~which is an~~ alternating flux to run along the middle leg magnetic circuit(1) by an exciting means(3b);

achieving magnetic non-balance condition due to collapse of the magnetic balance condition, which is caused by running detected current along a detected wire(6) passed through at least one of ~~a~~ the window which is formed by being surrounded by a first ~~an~~ outer leg magnetic circuit(2a) and the middle leg magnetic circuit(1) and ~~a~~ the window which is formed by being surrounded by a second ~~an~~ outer leg magnetic circuit(2b) and the middle leg magnetic circuit(1) to vary the magnetic reluctance of the first outer leg magnetic circuit(2a) and the second outer leg magnetic circuit(2b);

achieving magnetic re-balance condition by running balance recovery current along a balance recovery coil(5) to decrease the flux being generated along the middle leg magnetic circuit(1) in the condition that magnetic reluctance of the first outer leg magnetic circuit(2a) and the second outer leg magnetic circuit(2b) is varied, wherein the balance recovery current, which generates the flux of which the magnitude is as same as that of the flux being generated along the magnetic circuit around which the detected wire(6) is wound by being passed therethrough in the condition that the magnetic

reluctance of the first outer leg magnetic circuit(2a) and the second outer leg magnetic circuit(2b) is varied and the direction is reverse to that of the said flux, is run along the balance recovery coil(5) which is wound by being passed through the same window as the window through which the detected wire(6) is passed; and

detecting the detected current running along the detected wire(6) by detecting the balance recovery current running along the balance recovery coil(5) in the magnetic re-balance condition.

5. (Currently amended) A current sensor, comprising:

a first ~~one~~ magnetic circuit(1) having opposite ends;

second and third magnetic circuits(21a,21b) each having opposite ends, wherein the respective one ends of the second and third magnetic circuits(21a,21b) are connected with one end of the first magnetic circuit(1);

fourth and fifth magnetic circuits(22b,22a) each having opposite ends, wherein the respective one ends of the fourth and fifth magnetic circuits(22b,22a) are connected with the other end of the first magnetic circuit(1), and the other ends of the fourth and fifth magnetic circuits(22b,22a) are connected with the second and third magnetic circuits(21a,21b), respectively;

a sixth ~~one~~ magnetic circuit(2) having opposite ends, wherein one and the other ends of the sixth magnetic circuit(2) are connected with a contact between the second and fourth magnetic circuits(21a,22b) and a contact between the third and fifth magnetic circuits(21b,22a), respectively;

an exciting means(3) arranged to generate ~~a~~ the flux along the sixth magnetic circuit(2);

a flux detecting means(4) arranged to detect ~~a~~ the flux of the first magnetic circuit(1);

a drive means(7) for driving the exciting means(3); and

a detection circuit(8) connected with the flux detecting means(4) and outputting the electric signals interlocked with the flux being detected by the flux detecting means(4).

6. (Currently amended) A current sensor according to claim 5, wherein, in the case that the exciting means(3) is a coil, the coil is arranged to be passed at least one time through both of the window surrounded by the second and third magnetic circuits(21a,21b) and the sixth magnetic circuit(2) and the window surrounded by the fourth and fifth magnetic circuits(22a,22b) and the sixth magnetic circuit(2).

7. (Currently amended) A current sensor according to claims 5 ~~or~~ 6, wherein, in the case that the flux detecting means(4) is a coil, the coil is arranged to be passed at least one time through both of the window surrounded by the second and fourth magnetic circuits(21a,22b) and the first magnetic circuit(1) and the window surrounded by the third and fifth magnetic circuits(22a,21b) and the first magnetic circuit(1).

8. (Currently amended) A current sensor according to ~~any one of~~ claims 5 ~~to~~ 7,

wherein the first magnetic circuit(1), the second and fifth magnetic circuits(21a,22a), the third and fourth magnetic circuits(21b,22b), the sixth magnetic circuit(2) and the exciting means(3) form a magnetic bridge.

9. (Currently amended) A current sensor according to ~~any one of~~ claims 5 to 8, further comprising:

a balance recovery coil(5) arranged in any position in the magnetic bridge formed by the first magnetic circuit(1), the second and fifth magnetic circuits(21a,22a), the third and fourth magnetic circuits(21b,22b), the sixth magnetic circuit(2) and the exciting means(3);

a balance recovery current controlling circuit(9) for controlling the balance recovery current run along the balance recovery coil(5) to decrease the flux being detected by the flux detecting means(4), based on the electric signals being output from the detection circuit(8); and

a detected value outputting circuit(10) for outputting the balance recovery current value.

10. (Currently amended) A current detecting method, comprising:

achieving magnetic balance condition in which the flux by an exciting means(3) is not present in a first magnetic circuit(1), by properly selecting the magnetic reluctance of second, third, fourth and fifth magnetic circuits(21a,21b,22a,22b) to equalize magnetic potential of the opposite ends of the first magnetic circuit(1);

achieving magnetic non-balance condition due to collapse of the magnetic balance condition, which is caused by running detected current along a detected wire(6) passed through at least one of the window surrounded by the first, second and fourth magnetic circuits(21a,22b,1) and the window surrounded by the first, third and fifth magnetic circuits(21b,22a,1) to vary the magnetic reluctance of at least one of the second, third, fourth and fifth magnetic circuits(21a,22a,21b,22b); and

detecting the detected current running along the detected wire(6) by detecting a the flux which is generated along the first magnetic circuit(1) through achieving the magnetic non-balance condition, by a detection circuit(8) outputting the electric signals interlocked with the flux being detected by a flux detecting means(4).

11. (Currently amended) A current detecting method, comprising:

achieving magnetic re-balance condition by running balance recovery current along a balance recovery coil(5) to return to the magnetic reluctance prior to variation the varied magnetic reluctance of the magnetic circuit of which the magnetic reluctance is varied and thus decrease a the flux being generated along a first magnetic circuit(1) in the condition that the magnetic reluctance of at least one of second, third, fourth and fifth magnetic circuits(21a,22a,21b,22b) is varied, wherein the balance recovery current, which generates a first the flux of which the magnitude is as same as that of a second the flux being generated along the magnetic circuit around which a detected wire(6) is wound by being passed therethrough in the condition that the magnetic reluctance of at least one of the second, third, fourth and fifth magnetic circuits(21a,22a,21b,22b) is varied and the

direction is reverse to that of the second ~~said~~ flux, is run along the balance recovery coil(5) which is wound by being passed through the same window as the window through which the detected wire(6) is passed; and

detecting the detected current running along the detected wire(6) by detecting the balance recovery current running along the balance recovery coil(5) in the magnetic re-balance condition.

12. (Currently amended) A magnetic bridge, comprising:  
one middle leg magnetic circuit(1) having opposite ends;  
first and second~~two~~ outer leg magnetic circuits(2a,2b) each connected to one of  
the opposite~~with one and the other~~ ends of the middle leg magnetic circuit(1),  
respectively;

~~an~~ a first exciting means(3a) arranged in the first outer leg magnetic circuit(2a)  
and ~~an~~ a second exciting means(3b) arranged in the second outer leg magnetic  
circuit(2b);

a flux detecting means(4) arranged in the middle leg magnetic circuit(1); and  
drive means(7) for driving each of the exciting means(3a)~~and the exciting~~  
~~means(3b), respectively;~~

wherein the magnetic bridge achieves magnetic balance condition by generating a  
~~the~~ first excited flux which is an alternating flux to run along the middle leg magnetic  
circuit(1) by the first exciting means(3a) and generating a ~~the~~ second excited flux, of  
which the magnitude is as same as that of the first excited flux and the direction is reverse



to that of the first excited flux, which is an alternating flux to run along the middle leg magnetic circuit(1) by the second exciting means(3b).

13. (Currently amended) A magnetic bridge, comprising:

a first ~~one~~ magnetic circuit(1) having opposite ends;

second and third magnetic circuits(21a,21b) having opposite ends, wherein the respective one ends of the second and third magnetic circuits(21a,21b) are connected with one end of the first magnetic circuit(1);

fourth and fifth magnetic circuits(22b,22a) having opposite ends, wherein the respective one ends of the fourth and fifth magnetic circuits(22b,22a) are connected with the other end of the first magnetic circuit(1), and the other ends of the fourth and fifth magnetic circuits(22b,22a) are connected with the second and third magnetic circuits(21a,21b), respectively;

a sixth ~~one~~ magnetic circuit(2) having opposite ends, wherein one and the other ends of the sixth magnetic circuit(2) are connected with a contact between the second fourth magnetic circuits(21a,22b) and a contact between the third and fifth magnetic circuits(21b,22a), respectively;

an exciting means(3) arranged to generate a ~~the~~ flux along the sixth magnetic circuit(2);

a flux detecting means(4) arranged to detect the flux of the first magnetic circuit(1); and

a drive means(7) for driving the exciting means(3);

wherein the magnetic bridge achieves magnetic balance condition in which the flux by the exciting means(3) is not present in the first magnetic circuit(1), by properly selecting the magnetic reluctance of the second, third, fourth and fifth magnetic circuits(21a,21b,22a,22b) to equalize magnetic potential of the opposite ends of the first magnetic circuit(1).

14. (Currently amended) A magnetic bridge, comprising:

first and second magnetic circuits(21a,21b) having opposite ends, wherein one ends of the first and second magnetic circuits(21a,21b) are connected;

third and fourth magnetic circuits(22b,22a) having opposite ends, wherein one ends of the third and fourth magnetic circuits(22b,22a) are connected, and the other ends of the third and fourth magnetic circuits(22b,22a) are connected with the first and second magnetic circuits(21a,21b), respectively;

a fifth ~~one~~ magnetic circuit(2) having opposite ends, wherein one and the other ends of the fifth magnetic circuit(2) are connected with a contact between the first and third magnetic circuits(21a,22b) and a contact between the second and fourth magnetic circuits(21b,22a), respectively;

an exciting means(3) arranged to generate a ~~the~~ flux along the fifth magnetic circuit(2); and

a drive means(7) for driving the exciting means(3);

wherein the magnetic bridge achieves magnetic balance condition in which magnetic potential of the contact between the first and second magnetic circuits(21a,21b)

and the contact between the third and fourth magnetic circuits(22b,22a) is equalized by properly selecting the magnetic reluctance of the first, second, third and fourth magnetic circuits(21a,21b,22a,22b).

Respectfully submitted,



---

Patrick D. McPherson

Reg. No. 46,255

L. Lawton Rogers, III

Reg. No. 24,302

D. Joseph English

Reg. No. 42,514

Mark C. Comtois

Reg. No. 46,285

DUANE MORRIS LLP  
1667 K Street, N.W., Suite 700  
Washington, D.C. 20006  
Telephone: (202) 776-7800  
Telecopier: (202) 776-7801

Dated: February 18, 2005